

11

predetermined second radial thickness. The second predetermined radial thickness is at least equal to or greater than the predetermined radial thickness of the first sublayer 22. The second sublayer is uniformly connected to the first sublayer. Preferably at least one sublayer 29 is capable of dissipating electrostatic charge in the manner described previously; with the first sublayer 24 being preferred.

The first and second sublayers are generally composed of the same or similar melt-processible extrudable thermoplastic materials with the significant difference being the electrostatic dissipation capacity.

While preferred embodiments, forms an arrangement of parts of the invention have been described in detail, it will be apparent to those skilled in the art that the disclosed embodiments may be modified. Therefore, the foregoing description is to be considered exemplary rather than limiting, and the true scope of the invention is that defined in the following claims.

What is claimed is:

1. An elongated multi-layer fuel and vapor tube comprising:

a first layer disposed radially innermost having an inner surface capable of prolonged exposure to a fluid containing hydrocarbons, the first layer consisting essentially of a melt-processible thermoplastic, the melt processible thermoplastic selected from the group consisting of polyamides, thermoplastic elastomers, aromatic polyketones and mixtures thereof,

a second layer uniformly connected to the first layer in co-extruded relationship therewith, the second layer consisting essentially of an extrudable, melt-processible non-polyester, non-alcoholic thermoplastic material capable of sufficiently permanent laminar connection with the first layer so as to prevent delamination from the first layer during a desired lifetime of the tube;

a third layer uniformly connected to the second layer, the third layer consisting essentially of an extrudable melt-processible thermoplastic having as a major constituent a thermoplastic material selected from the group consisting of thermoplastic elastomers, polyamides and mixtures thereof,

wherein the thermoplastic material of the second layer contains at least one fluoroplastic constituent which is chemically dissimilar from the thermoplastic material of the third layer in alloyed combination therewith; and

wherein the elongated multi-layer tube has a hydrocarbon permeation level below about 0.5 g/m² per 24 hour interval.

2. The elongated multi-layer tube of claim 1 further comprising at least one intermediate bonding layer consisting essentially of a melt-processible thermoplastic selected from the group consisting of polyvinylidene fluoride, polyvinyl fluoride, copolymers of ethylene tetrafluoroethylene, blends of urethane and polyvinyl acetate and mixtures thereof, the intermediate bonding layer interposed between at least two of said layers of said multi-layer tube.

3. The elongated multi-layer tube of claim 2 wherein thermoplastic material employed in the second layer consists essentially of polymeric alloy composed of a melt-processible polyamide and a fluoroplastic material.

4. The elongated multi-layer tube of claim 3 wherein the fluoroplastic material employed in the second layer is selected from the group consisting of polyvinylidene fluoride, polyvinyl fluoride, copolymers of ethylene tetrafluoroethylene, and mixtures thereof.

12

5. The elongated multi-layer tube of claim 4 wherein the polyamide employed in the second layer is selected from the group consisting of Nylon 12, Nylon 11, Nylon 6, Nylon 10, 12, and mixtures thereof.

6. The elongated multi-layer tube of claim 2 wherein the thermoplastic material employed in the first layer is selected from the group consisting of fluoroplastics, thermoplastic elastomers, polyamides and mixtures thereof.

7. The elongated multi-layer tube of claim 6 wherein the thermoplastic material of the first layer is a polyamide selected from the group consisting of nylon 11, nylon 12, nylon 6, nylon 6.6, and mixtures thereof.

8. The elongated multi-layer tube of claim 6 wherein the elastomer thermoplastic material of the first layer is a thermoplastic elastomer selected from the group consisting of Sarlink, Kraton, Vichem, Santoprene, and mixtures thereof.

9. The elongated multi-layer tube of claim 6 wherein the thermoplastic material employed in the first layer is a fluoroplastic selected from the group consisting of copolymers of ethylene tetrafluoroethane, polyvinylfluoride, polyvinylidene fluoride and mixtures thereof.

10. The elongated multi-layer tube of claim 2 wherein at least one layer is capable of dissipating electrostatic charge.

11. The elongated multi-layer tube of claim 10 wherein at least the first layer is capable of dissipating electrostatic charge.

12. The elongated multi-layer tube of claim 11 wherein electrostatic charge dissipation measured as surface resistivity is less than 1×10⁶ ohms per square.

13. The elongated multi-layer tube of claim 10 wherein at least one layer contains conductive media in a quantity to dissipate sufficient electrostatic charge to prevent a discharge event.

14. The elongated multi-layer tube of claim 13 wherein at least one layer contains less than about 7% by volume conductive media selected from the group consisting of copper, silver, gold, nickel, silicon, carbon black, and mixtures thereof.

15. An elongated multi-layer tube comprising:

a first layer disposed radially innermost having an inner surface capable of prolonged exposure to a fluid containing hydrocarbons, the first layer consisting essentially of a melt-processible thermoplastic;

a second layer uniformly connected to the first layer in co-extruded relationship therewith, the second layer consisting essentially of an extrudable, melt-processible non-polyester, non-alcoholic thermoplastic material capable of sufficiently permanent laminar connection with the first layer so as to prevent delamination from the first layer during a desired lifetime of the tube;

a third layer uniformly connected to the second layer, the third layer consisting essentially of an extrudable melt-processible thermoplastic having as a major constituent a thermoplastic material selected from the group consisting of thermoplastic elastomers, polyamides and mixtures thereof,

wherein the thermoplastic material of the second layer contains at least one fluoroplastic constituent which is chemically dissimilar from the thermoplastic material of the third layer in alloyed combination therewith; and

wherein the thermoplastic material employed in the second layer consists essentially of a first melt-processible thermoplastic compound having at least two isocyanate groups and a second melt-processible thermoplastic

13

compound selected from the group consisting of thermoplastic elastomers, polyamides and mixtures thereof wherein the first and second melt-processible materials are in alloyed relationship with one another.

16. The elongated multi-layer tube of claim 15 wherein the melt-processible thermoplastic material employed in the second layer comprises between about 50 to 99% by weight polyamide and between about 1 to 40% by weight of a compound having at least two isocyanate groups.

17. The elongated multi-layer tube of claim 16 wherein the compound containing at least two isocyanate groups has at least one functional group selected from the group consisting of isocyanate, urethane, acrylated urea, biuret, carbodiimides and esters.

18. The elongated multi-layer tube of claim 16 wherein the compound having at least two isocyanate groups is selected from the group consisting of isophorone diisocyanate, an isocyanurate derived from isophorone diisocyanate, and mixture thereof.

19. The elongated multi-layer tube of claim 16 wherein the polyamide employed in the second layer is selected from the group consisting of Nylon 11, Nylon 12, Nylon 6 and mixtures thereof.

20. The elongated multi-layer tube of claim 15 wherein at least one layer is capable of dissipating electrostatic charge in a range between about 1×10^4 ohm/square and about 1×10^6 ohm/square.

21. The elongated multi-layer tube of claim 20 wherein at least the first layer is capable of dissipating electrostatic charge.

22. The elongated multi-layer tube of claim 21 wherein the first layer comprises:

a first sublayer disposed radially innermost having a predetermined first radial thickness and an inner surface capable of prolonged exposure to a fluid containing hydrocarbons; and

a second sublayer having a predetermined second radial thickness, the second predetermined thickness being at least equal to the first predetermined radial thickness, the second sublayer uniformly connected to the first sublayer;

wherein at least the first sublayer is capable of dissipating electrostatic charge.

23. The elongated multi-layer tube of claim 20 wherein at least one layer contains conductive media in a quantity to dissipate sufficient electrostatic charge to prevent a discharge event.

24. The elongated multi-layer tube of claim 23 wherein at least one layer contains less than about 7% by volume conductive media selected from the group consisting of copper, silver, gold, nickel, silicon, carbon black, and mixtures thereof.

25. An elongated multi-layer tube comprising:

a first layer disposed radially innermost having an inner surface capable of prolonged exposure to a fluid containing hydrocarbons, the first layer consisting essentially of a melt-processible thermoplastic;

a second layer uniformly connected to the first layer, the second layer consisting essentially of an extrudable, melt-processible non-polyester, non-alcoholic thermoplastic material capable of sufficiently permanent laminar connection with the first layer so as to prevent delamination from the first layer during a desired lifetime of the tube, wherein the thermoplastic material consists essentially of:

a) a first melt-processible compound, the first melt-processible compound being non-polyester, non-alcoholic and having at least two isocyanate groups; and

14

b) a second melt-processible thermoplastic compound selected from the group consisting of thermoplastic elastomers, polyamides and mixtures thereof, wherein the first and second compound are in alloyed relationship; and

a third layer uniformly connected to the second layer, the third layer consisting essentially of an extrudable melt-processible thermoplastic having as a major constituent a thermoplastic material selected from the group consisting of thermoplastic elastomers, polyamides and mixtures thereof.

26. The elongated multi-layer tube of claim 25 wherein the melt-processible thermoplastic material employed in the second layer comprises between about 50 to about 99% by weight polyamide and between about 1 to about 40% by weight of a compound having at least two isocyanate groups.

27. The elongated multi-layer tube of claim 26 wherein the compound containing at least two isocyanate groups has at least one functional group selected from the group consisting of isocyanate, urethane, acrylated urea, biuret, carbodiimides and esters.

28. The elongated multi-layer tube of claim 27 wherein at least one layer is capable of dissipating electrostatic charge in a range between about 1×10^4 ohm/square to about 1×10^6 ohm/square.

29. The elongated multi-layer tube of claim 26 wherein the compound having at least two isocyanate groups is selected from the group consisting of isophorone diisocyanate, an isocyanurate derived from isophorone diisocyanate, and mixture thereof.

30. The elongated multi-layer tube of claim 26 wherein the second constituent of the thermoplastic material of the second layer is polyamide selected from the group consisting of Nylon 11, Nylon 12, Nylon 6 and mixtures thereof.

31. The elongated multi-layer tube of claim 26 further comprising at least one intermediate bonding layer consisting essentially of a melt-processible thermoplastic selected from the group consisting of polyvinylidene fluoride, polyvinyl fluoride, copolymers of ethylene tetrafluoroethylene, blends of urethane and polyvinyl acetate and mixtures thereof, the intermediate bonding layer interposed between at least two of said layers of said multi-layer tube.

32. The elongated multi-layer tube of claim 26 wherein the thermoplastic material employed in the first layer is selected from the group consisting of fluoroplastics, thermoplastic elastomers, polyamides and mixtures thereof.

33. The elongated multi-layer tube of claim 32 wherein the thermoplastic material of the first layer is a polyamide selected from the group consisting of nylon 11, nylon 12, nylon 6, nylon 6.6, and mixtures thereof.

34. The elongated multi-layer tube of claim 32 wherein the elastomer thermoplastic material of the first layer is a thermoplastic elastomer selected from the group consisting of Sarlink, Kraton, Vichem, Santoprene, and mixtures thereof.

35. The elongated multi-layer tube of claim 32 wherein the thermoplastic material employed in the first layer is a fluoroplastic selected from the group consisting of copolymers of ethylene tetrafluoroethane, polyvinylfluoride, polyvinylidene fluoride and mixtures thereof.

36. The elongated multi-layer tube of claim 35 wherein at least the first layer is capable of dissipating electrostatic charge.

37. The elongated multi-layer tube of claim 35 wherein the first layer comprises:

a first sublayer disposed radially innermost having a predetermined first radial thickness and an inner sur-

15

face capable of prolonged exposure to a fluid containing hydrocarbons; and

- a second sublayer having a predetermined second radial thickness, the second predetermined thickness being at least equal to the first predetermined radial thickness, the second sublayer uniformly connected to the first sublayer;

wherein at least the first sublayer is capable of dissipating electrostatic charge in a range between about 1×10^6 ohm/square and about 1×10^9 ohm/square.

38. The elongated multi-layer tube of claim 35 wherein at least one layer contains conductive media in a quantity to dissipate sufficient electrostatic charge to prevent a discharge event.

39. The elongated multi-layer tube of claim 38 wherein at least one layer contains less than about 7% by volume conductive media selected from the group consisting of copper, silver, gold, nickel, silicon, carbon black, and mixtures thereof.

40. An elongated multi-layer tube comprising:

- a first layer disposed radially innermost having an inner surface capable of prolonged exposure to a fluid containing hydrocarbons, the first layer consisting essentially of a melt-processible thermoplastic; and

- a second layer uniformly connected to the first layer, the second layer consisting essentially of an extrudable, melt-processible non-polyester, non-alcoholic thermoplastic material capable of sufficiently permanent laminar connection with the first layer so as to prevent delamination from the first layer during a desired lifetime of the tube, wherein the thermoplastic material is a melt-processible thermoplastic alloy consisting essentially of:

16

- a) from about 1 to about 40% by weight of a melt-processible compound having at least two isocyanate groups, and at least one functional group selected from the group consisting of isocyanate, urethane, acrylated urea, biuret, carbodiimides and esters; and
b) from about 50 to about 99% of a thermoplastic compound selected from the group consisting of thermoplastic elastomers, polyamides and mixtures thereof.

41. The elongated multi-layer tube of claim 40 wherein the compound having at least two isocyanate groups is selected from the group consisting of isophorone diisocyanate, an isocyanurate derived from isophorone diisocyanate, and mixtures thereof.

42. The elongated multi-layer tube of claim 41 wherein the second constituent of the thermoplastic material of the second layer is polyamide selected from the group consisting of Nylon 11, Nylon 12, Nylon 6 and mixtures thereof.

43. The elongated multi-layer tube of claim 40 further comprising at least one intermediate bonding layer consisting essentially of a melt-processible thermoplastic selected from the group consisting of polyvinylidene fluoride, polyvinyl fluoride, copolymers of ethylene tetrafluoroethylene, blends of urethane and polyvinyl acetate and mixtures thereof, the intermediate bonding layer interposed between said first layer and said second layer.

44. The elongated multi-layer tube of claim 40 wherein the thermoplastic material of the first layer is selected from the group consisting of nylon 11, nylon 12, nylon 6, nylon 6.6, Sarlink, Kraton, Vichem, Santoprene, and mixtures thereof.

* * * * *